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COLORED STONES AND ORGANIC MATERIALS

Copal vs. amber. M. C. Pedersen [maggiecp@btinternet.com] and B. Williams, *Gems & Jewellery*, Vol. 20, No. 2, 2011, pp. 20–24.

Correctly identifying copal and amber can be difficult, as standard gemological tests are not very useful for resins. In addition, the treatments they may undergo are complex and numerous. Understanding the differences between these resins, as well as their treatments, is vital to ensuring proper disclosure. In this article, the characteristics of natural/treated amber and copal are reported from gemological tests specific to organics, as well as more advanced FTIR, Raman, and cross-polarized filter testing. A discussion of the results helps provide insight as to which tests can correctly identify an unknown specimen and any possible treatments. MK

Genesi e classificazione dei diaspri (II parte) [Formation and classification of jasper (Part II)]. M. C. Venuti, *Rivista Gemmologica Italiana*, Vol. 5, No. 2, 2010, pp. 133–158 [in Italian].

Today's nomenclature of jasper is a motley collection of varietal and trade names rather than a well-ordered classification system. The author proposes a classification based on formation, surroundings, and processes. He distinguishes four types: *Oceanic jasper* (formed by organic sedimentation), *volcanic jasper* (silicification of volcanic rocks), *pseudomorphous jasper* (silicification after fossils), and *chemical jasper* (chemical precipitation from silicic solutions and gels). For all four types, various sequences of formation are described. Generally, they include different mechanisms of silica concentration, from single molecules resolved in aqueous solution to the crystallization of jasper (in most cases including opal as a transitional stage). As formation conditions can vary widely and the pro-

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cesses (especially hydration and dehydration) can be repeated or reversed several times, jaspers accordingly show many different patterns and colors. RT

Genesi della agate (I parte) [Formation of agate (Part I)]. M.

C. Venuti, *Rivista Gemmologica Italiana*, Vol. 5, No. 3, 2010, pp. 213–225 [in Italian].

The diversity of agates makes their classification difficult. The author's investigations reveal four types of layers that comprise all agates. The first type is a clear chalcedony layer that forms the outer part of every specimen. It is always the first layer to form, and is generally transparent and nonbanded, with a spherulitic texture. It can be as thin as 1 mm or fill the entire cavity. Only within this layer do features develop such as moss, plumes, and dendrites. The second type consists of the banded layers characteristic of agates. They can be concentric, parallel ("Uruguay type"), or hemispherical. The third type is rare and forms white, often interrupted horizontal bands or massive parts of the agate. The fourth consists of macro-crystalline quartz, sometimes amethyst. While the clear chalcedony layer always occurs, but only once, the other layers may form consecutively or simultaneously and be repeated several times in the same agate.

RT

Getting a feel for organics. M. C. Pedersen [maggiecp@btinternet.com], *Gems & Jewellery*, Vol. 19, No. 3, 2010, pp. 14–15.

Organic gems and their imitations have been around for countless years, and this article explains how general observations and common sense can help in the identification process. While sight is the sense most often relied upon, touch, smell, and sound can also be helpful as long as there is some basic knowledge of organic gems. Provenance can also help distinguish some organic gems. Yet the author cautions that there will be times when more sophisticated testing or a gemological laboratory may be required for conclusive identification. MK

Luminescence of gem opals: A review of intrinsic and extrinsic emission. E. Gaillou, E. Fritsch, and F. Mas-

suyeu, *Australian Gemmologist*, Vol. 24, No. 8, 2011, pp. 200–201.

Not all opals display luminescence, but when they do their emission colors are typically green or a chalky white to blue. Rarer orange emission is restricted to opal with a pink bodycolor. The researchers examined 20 strongly luminescent opals from a range of localities using a Fluorolog 3 spectrofluorometer to determine the cause(s) of their luminescence.

Blue emission resulted from "the nano-structured nature of silica in opal, offering abundant surface with dangling bonds." Green emission, often seen in common opal, was related to extrinsic uranium impurities, and specimens exhibited emission bands characteristic of the

"uranyl group in a phosphate environment." Orange emission was caused by quinones, or "fossil organic molecules" that are absorbed into phyllosilicate inclusions in the opal.

For all three types of luminescence, concentrations of iron ranging from 1000 to 2000 ppm will suppress emissions. Furthermore, all three basic emissions have the capacity to mix in different proportions and subsequently exhibit various combined colors. AB

DIAMONDS

Diamond crystals and their mineral inclusions from the Lynx kimberlite dyke complex, central Quebec. A.

D. van Rythoven, T. E. McCandless, D. J. Schulze, A. Bellis, L. A. Taylor, and Y. Liu, *Canadian Mineralogist*, Vol. 49, No. 3, 2011, pp. 691–706.

The Lynx kimberlite is located in the Otish Mountains of central Quebec, within 2 km of the Renard kimberlite cluster. Yet diamonds from these two deposits differ in physical characteristics, mineral inclusions, and geologic ages. Test sampling of ~500 tons of Lynx kimberlite ore yielded nearly 6,600 macrodiamonds. A 22 ct pale brown octahedron is the largest crystal found to date in the province. There were two main diamond morphologies, with 41% being octahedra and the remainder being partially resorbed tetrahedra. Typical colors include brown, gray, and colorless. Cathodoluminescence imaging of flat plates cut from 20 crystals revealed various patterns of deformation and resorption, as well as oscillatory growth zoning. Primary mineral inclusions consisted of olivine, Cr-diopside, Cr-pyrope, orthopyroxene, omphacite, and sulfide minerals. Data obtained from these inclusions suggest the diamonds formed at a depth of 180–190 km in the lithospheric mantle. JES

Peculiarities of diamond from the commercial deposits of

Russia. G. Y. Kriulina [galinadiamond@gmail.com], V. K. Garanin, A. Y. Rotman, and O. E. Koval'chuk, *Moscow University Geology Bulletin*, Vol. 66, No. 3, pp. 171–183.

This comprehensive article presents morphological and spectroscopic characteristics of more than 12,000 diamond crystals from several Russian deposits in the Arkhangelsk diamond province (ADP) and the Yakutia diamond province (YDP). Most had type I morphology according to Orlov's classification. Dodecahedral crystals were dominant in the ADP, while octahedral crystals were more common in the YDP. A rhombic-dodecahedral habit characterized diamonds from the Lomonosov deposit (ADP). The Zolotitskoe field and the Grib pipe (both ADP) had a higher percentage of cubic crystals. About half of the diamonds from the ADP were structurally homogenous, featuring a single growth habit. Some crystals from Lomonosov showed multiple growth habits, trending from

octahedral to cubic to fibrous; the opposite trend was observed in diamonds from the YDP.

Many rounded dodecahedral crystals from the Karpinsky-1 pipe and the Zolotitskoe field showed oxidizing dissolution traces, indicating their formation in saline fluids. However, crystals from the Grib pipe showed poorly developed resorption features with negative trigons, and reflect a less oxidative diamond-forming environment. Large crystals with numerous deep cavities were prevalent in the Snegurochka, Kol'tsovskaya, and Pervomaiskaya pipes.

Diamonds from the Arkhangelskaya, Karpinsky-1, and Karpinsky-2 pipes exhibited yellow and yellow-green luminescence. Most crystals from the Lomonosov, Pionerskaya, and Grib pipes and from the Mirninskoe field displayed unevenly distributed blue and violet luminescence. Some Mirninskoe diamonds also showed green luminescence with a pink peripheral zone. Most samples from the Nakyn field and the Botuobinskaya pipe exhibited violet luminescence. A small percentage of diamonds from the Jubileynaya (Yubileynaya) and Komsomolskaya pipes showed pink luminescence, while very few showed orange. The authors also observed a relationship between crystal habit and luminescence. For example, octahedrons from the Mir pipe tended to have pink luminescence while dodecahedrons fluoresced blue; for crystals that combined these two habits, the luminescence was yellow-green.

Electron paramagnetic resonance (EPR) spectroscopy revealed that diamonds from Internationalnaya, Lomonosov, and Pionerskaya possess similar paramagnetic centers—mainly P1, resulting from single-substituted nitrogen atoms. The P2 center, which is related to aggregated nitrogen atoms, was observed in most of the Grib diamonds. The N2 center, related to plastic deformation, was abundant in Grib diamonds but absent from the Pomorskaya samples. The M2 center, also related to plastic deformation, was found in pink-violet diamonds from the Internationalnaya pipe. Nickel-related paramagnetic centers such as NE1, NE2, and M1 were detected only in diamonds from Jubileynaya.

Based on their IR spectra, the YDP diamonds contained higher concentrations of nitrogen B-aggregates than those from the ADP. The Lomonosov and Grib diamonds were rich in hydrogen and platelets but contained fewer nitrogen aggregates. Samples from Pomorskaya, Karpinsky-1, and Arkhangelskaya had the highest concentrations of nitrogen A-aggregates (1,200, 1,100, and 950 ppm, respectively). The hydrogen, platelet, and B-aggregate concentrations in stones from the Mir pipe were similar to those from Internationalnaya and Butuobinskaya. Diamonds from the Komsomolskaya pipe contained A-aggregates with strong platelet bands but very weak or nonexistent hydrogen bands. The strongest platelet and hydrogen bands were observed in Jubileynaya crystals.

KSM

Phosphorescence in type IIb diamonds. S. Eaton-Magaña [smagana@gia.edu] and R. Lu, *Diamond and Related Materials*, Vol. 20, No. 7, 2011, pp. 983–989, <http://dx.doi.org/10.1016/j.diamond.2011.05.007>.

Phosphorescence spectroscopy was performed on 354 type IIb and seven type IIa diamonds, along with 24 HPHT-treated diamonds and 18 HPHT-grown synthetics. The phosphorescence in type IIb diamonds is due to a donor (most likely nitrogen) and acceptor (boron) pair recombination. In this mechanism, holes bound to acceptors and electrons bound to donors recombine and emit light with an energy corresponding to the difference between the energies of the isolated donor and acceptor, plus an electrostatic correction.

The only phosphorescence bands observed in the natural diamonds were centered at 500 and 660 nm. The relative intensity and half-life of these measured bands corresponded well to their boron concentration. None of the treated or synthetic diamonds showed the 660 nm band. However, these samples did have the 500 nm band, with a much higher intensity in the synthetics. The phosphorescence spectra were correlated to data collected from infrared absorption and photoluminescence spectroscopy, and these results provide additional evidence for the mechanism responsible for the observed phosphorescence.

GL

GEM LOCALITIES

Alexandrite and colour-change chrysoberyl from the Lake Manyara alexandrite-emerald deposit in northern Tanzania. K. Schmetzer [schmetzerkarl@hotmail.com] and A.-R. Malsy, *Journal of Gemmology*, Vol. 32, No. 5–8, 2011, pp. 179–209.

Trace amounts of Cr are the principal cause of the green color in emerald and the color change in alexandrite; Cr often predominates over V by a factor of five. Both gems require the simultaneous presence of Be and Cr for their formation, and it is not uncommon for them to occur in proximity to one another (but not in contact).

In the Lake Manyara mining area, emeralds are associated with pegmatitic intrusions and alexandrite crystals are found in adjacent phlogopite-bearing schist that formed from the metasomatism of mafic or ultramafic rocks by the pegmatites. This metamorphic-metasomatic geologic setting is similar to that found in the alexandrite-emerald belt of the Russian Urals and Novello, Zimbabwe. Due to overlapping concentrations, contents of Cr, V, and Fe in these gems should not be considered distinctive criteria for source determination.

Lake Manyara alexandrite shows enormous variability in morphology, including the presence of single crystals and a wide range of twins (e.g., contact, penetration, and cyclic twins, called *trillings*) developed in two major habits: one tabular parallel to the *a* pinacoid, the other

columnar along the a-axis. Dozens of color photomicrographs and schematic drawings illustrate not only these external morphologies but also their corresponding growth structures in both reflected and transmitted light. Numerous inclusions are discussed, including phlogopite, apatite, and zircon (surrounded by tension cracks), as well as partially healed fractures with residual fluid inclusions and two-phase inclusions within negative crystals. Milky white zones were caused by channels running parallel to the a-axis, occasionally in combination with negative crystals along the a plane.

The complexity of alexandrite's color-change phenomenon was studied in relation to colorimetric issues using the CIELAB color circle. The color changes observed in alexandrite and color-change chrysoberyl—and what distinguishes them from one another—are controversial and of great interest to the trade. They are extremely variable and relate directly to Cr contents and the orientation of the table facet with respect to the crystallographic axes.

ERB

Chemical and growth zoning in trapiche tourmaline from Zambia – A re-evaluation. K. Schmetzer [schmetzerkarl@hotmail.com], H.-J. Bernhardt, and T. Hainschwang, *Journal of Gemmology*, Vol. 32, No. 5–8, 2011, pp. 151–173.

In the last several years, tourmaline has been added to the short list of trapiche minerals, the most commonly known being emerald from Colombia and ruby from Mong Hsu, Myanmar. When slices of Zambian trapiche tourmaline are cut perpendicular to the c-axis, two different patterns can result—a three-rayed fixed star with three transparent sectors between the rays, or (most commonly) a three-rayed pattern in the center of the slice surrounded by six transparent sectors, with six boundaries between the center and the rim and between the six sectors of the rim.

The complex chemical and structural trapiche pattern is consistent with the formation of tourmaline crystals in a two-step process: the skeletal growth of Na-rich dravite in the first phase and subsequent layer-by-layer growth of a second tourmaline generation beginning with Ca-rich fluor-uvite followed sequentially by more Na-rich dravite.

The dominant external crystal forms of the trapiche tourmaline include the hexagonal prism $a\{11\bar{2}0\}$, the positive pyramids $r\{10\bar{1}1\}$ and $o\{02\bar{2}1\}$, and the negative pyramid $\bar{r}\{01\bar{1}\bar{1}\}$. The trapiche pattern occurs when high concentrations of liquid and mineral inclusions are trapped along narrow growth boundaries between pyramidal and prismatic growth sectors, and where elongated channels or voids extend into the surrounding tourmaline sectors perpendicular to the dominant crystal forms mentioned above. They are chemically zoned with isomorphic substitutions of Ca by Na and Mg by Al (which is characteristic for tourmalines of the uvite-dravite solid-solution

series); Na increases while Ca decreases from core to rim. However, at the boundaries between different growth sectors (forming the trapiche pattern), compositions were found with higher Na and lower Ca than in the adjacent pyramidal and prismatic growth sectors. The green coloration of the tourmaline is caused by minor amounts of V and Cr.

The article contains dozens of annotated color photos, illustrations, and graphical analyses that are helpful for understanding the complexities of the chemical and growth zoning.

ERB

INSTRUMENTS AND TECHNIQUES

Detection and analysis of diamond fingerprinting feature and its application. X. Li, G. Huang [tshgl@tsinghua.edu.cn], Q. Li, and S. Chen, *Journal of Physics: Conference Series*, Vol. 277, 2011, pp. 1–9, <http://dx.doi.org/10.1088/1742-6596/277/1/012018>.

This article presents an innovative theoretical and tested model for fingerprinting faceted diamonds, and notes two major improvements over a space-frequency-based approach. The authors detail how a diamond's fingerprint is obtained by directing parallel light beams toward the table facet. Using an arrangement of concave-convex lenses, Fourier transform methods, and an efficient software interface, a unique spatial frequency spectral analysis of a diamond's surface structure of reflected light is computed—its “fingerprint.”

The authors discuss key formulas for the superposition relationships between complex amplitude distributions on diffraction and back focal planes, the coaxial light intensity distributions, the actual mathematical model of the fingerprinting map, and the assessment and control of image signal-to-noise issues. The software platform is VC2003 (Visual Studio 2003) linking to the OpenCV library, which allows customization for real-time image collection and preview, analysis, and archiving with additional information (owner, carat weight, provenance, etc.), as well as background noise removal (to generate clearer fingerprints). The authors provide an algorithm for accurate analysis of diamond spectral data by a “radius comparison method,” using compared sequences of mean square error (MSE) and maximum error (ME).

The model's multi-sampled robustness is tested by employing MSE and ME, which yields good specificity and space-invariance. In other words, there is minimal variance from positional changes of a diamond placed within the apparatus (measured on axes called *center translation invariance* and *rotation invariance*), resulting in reliable fingerprinting.

The usefulness of the findings is discussed in terms of a real-time, accurate, and relatively simple technology to aid in countering smuggling, theft, and other security issues where diamond fingerprinting is useful.

ERB

Jade detection and analysis based on optical coherence tomography images. S. Chang [shoude.chang@nrc.ca], Y. Mao, G. Chang, and C. Flueraru, *Optical Engineering*, Vol. 49, No. 6, 2010, pp. 1–8, <http://dx.doi.org/10.1117/1.3449112>.

Optical coherence tomography (OCT) is a fundamentally new type of optical sensing technology that can perform high-resolution, cross-sectional sensing of the internal structure of materials. Advantages over other volume-sensing systems include: higher resolution, non-invasive noncontact, speed, fiber-optic delivery, and no harmful radiation. The micron-level resolution makes it unique among tomographic imaging technologies. Jade is almost translucent to IR wavelengths and has various types of internal textures. The textural features of various jades were analyzed using their OCT signals. Six parameters were used to numerically describe their texture patterns. 3-D volume data were generated through swept-source OCT with a depth resolution of 4 μm and penetration range of 5 mm. OCT can be used for the detection, classification, counterfeit recognition, and guided artistic carving of jade. GL

JEWELRY HISTORY

I vaghi di collana in pietra nella storia [Gemstone beads through history]. M. C. Venuti, A. Garuti, and G. Romiti. *Rivista Gemmologica Italiana*, Vol. 5, No. 3, 2010, pp. 197–212 [in Italian].

The authors survey the use of beads in jewelry. About 100,000 years ago, snail shells were used for bead chains, but 9,000 years ago they were replaced by quartz, followed by agate, chalcedony, jasper, and others. Paralleling human migration, beads spread from Africa to the Middle East, India, and eventually the rest of the world from East Asia to the Mediterranean Sea. Over the course of time, the methods of bead production (drilling, polishing, and dyeing) became increasingly sophisticated. An important production center is India, especially Khambar, where this ancient tradition lives on.

The authors also discuss different types of beads, ancient versus modern beads, and the identification of treatments and imitations. RT

JEWELRY RETAILING

Training helps sales force to sparkle. D. Pollitt, *Human Resource Management International Digest*, Vol. 19, No. 1, 2011, pp. 15–16.

British-based Aurum, a luxury jewelry retail chain, improved year-on-year sales by revamping its sales training from a product-based approach to one that developed customer interaction skills. The transformation encompassed the entire buying experience, not just the sales

close. This meant listening to customers to gauge their needs and help them gain confidence in their decision before attempting to close. The program, developed by a consultant, consisted of a two-day e-learning module for all 1,600 employees, followed by support meetings with senior and regional management. RS

SYNTHETICS AND SIMULANTS

And now composite chalcedony. G. Choudhary [gagan@gjepcindia.com], *Gems & Jewellery*, Vol. 19, No. 4, 2010, pp. 28–30.

This article briefly reports on the examination and identification of three chalcedony composites held together in a polymer-based matrix. The specimens varied in color: dark green with a gold matrix, light green with a silvery white matrix, and orange with a silvery white matrix. These pieces, which were submitted to the author's gem testing laboratory for identification, underwent standard gemological testing as well as FTIR and EDXRF analysis. Key properties are listed, and the study concluded that these specimens are similar in nature to composite turquoise with metallic veins (described by the author in the Summer 2010 *G&J*, pp. 106–113). MK

Characterization of a new synthetic fancy yellow diamond. V. Rolandi, A. Brajkovic [anna.brajkovic@unimib.it], A. Giorgioni, A. Malossi, R. Scotti, *Gemmologie: Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 60, No. 1–2, 2011, pp. 9–24.

Malossi Gemmecreate, an Italian company from Milan, is marketing faceted gem-quality yellow synthetic diamonds in the 1–2 ct range. This report provides some details of the crystal growth method and the results of gemological and spectroscopic measurements for identification purposes.

Malossi synthetic diamonds are produced in eastern Europe using an HPHT technique with a split-sphere or BARS press. After growth, they are annealed at high temperature and pressure. The growth method employs a truncated tetragonal bipyramidal growth cell rather than a cubic growth cell, to more closely approximate the crystal habit adopted during natural diamond formation, resulting in minimal weight loss during cutting. The exact growth process is a Malossi trade secret, but some details are revealed. The growth temperature ranges from 1360°C to 1680°C, at a pressure of 60–70 kbar. The flux is composed of alkali carbonates and the carbon source is pure graphite, to which nickel and other metal growth catalysts are added. The finished crystals weigh ~3.0 ct and take about 72 hours to grow. The post-growth processing for improving color and transparency includes heating the crystals to between 1800°C and 2000°C for 10–15 hours while cycling the pressure as high as 80 kbar.

Gemological characterization of the finished stones showed a specific gravity value identical to that of natural diamond, with uniform color and clarity ranging from IF to VS. The samples displayed cloud-like inclusions of oriented and arranged pinpoint and needle-like diamond crystals, weak anomalous double refraction, and uniform bright green UV fluorescence with a pattern common to synthetic diamonds grown with a nickel catalyst. Spectroscopic techniques employed included FTIR, UV-Vis-NIR, photoluminescence, and electron spin resonance spectroscopy as well as cathodoluminescence imaging. These techniques revealed characteristic nickel signatures and identified the synthetic diamonds as almost exclusively type IaA. JS-S

TREATMENTS

Diffusion of chromium in sapphire: The effects of electron beam irradiation. Y.-K. Ahn, J.-G. Seo, and J.-W. Park [jwpark@hanyang.ac.kr], *Journal of Crystal Growth*, Vol. 326, No. 1, 2011, pp. 45–49, <http://dx.doi.org/10.1016/j.jcrysgro.2011.01.049>.

This study evaluated chromium diffusion of sapphire using different treatment methods. Two samples were irradiated with 10 MeV of electrons at fluences of $2 \times 10^{17} \text{ cm}^{-2}$ for one hour. One of the samples was coated with Cr^{3+} prior to irradiation. Annealing experiments were performed on these, as well as an untreated and uncoated sapphire, at temperatures ranging from 1,773 to 1,923 K for 200 hours under an oxidation condition of 1 atm. The diffusion of chromium in sapphire was profiled using SEM-EDX spectroscopy, and Arrhenius equations for the diffusion coefficient were obtained.

Chromium penetrated deepest within the coated and electron beam-irradiated sapphire, followed by the uncoated electron beam-irradiated sample, and finally the uncoated non-irradiated sapphire. Photoluminescence spectroscopy showed that samples irradiated with electron beams had higher peak intensities than the non-irradiated sample, indicating a greater abundance of anion and cation vacancies. Irradiated samples therefore showed

deeper diffusion of chromium. It also became evident that an even coating of chromium on the sapphire enhanced diffusion. GL

MISCELLANEOUS

Uplifting the Earth: The ethical performance of luxury jewelry brands. I. Doyle [idoyle@lifeworth.com] and J. Bendell, *Lifeworth Consulting*, June 2011, pp. 1–58, www.lifeworth.com/consult/wp-content/uploads/2011/06/UpliftingTheEarth.pdf.

Consumer concerns over the ethical sourcing of gemstones and precious metals have pushed brands to redefine their business practice. This is the first study to benchmark luxury jewelry brands on their corporate responsibility. Ten of them were analyzed for their ethical, social, and environmental performance, with particular attention on the ethical sourcing of raw materials. The brands, selected for their renown and focus on fine gemstones, provided a cross-section of this sector: Boucheron, Buccellati, Bulgari, Cartier, Chanel, Chopard, Graff, Harry Winston, Piaget, and Van Cleef & Arpels.

The study revealed that Boucheron and Cartier are the brands most active in addressing corporate responsibility throughout the supply chain, while the others are either inactive or only partially active. (Although not part of the study, Tiffany & Co. was commended for its practices.) By examining efforts of responsible jewelry pioneers, this report outlines a vision of ethical excellence in luxury jewelry where brands can “uplift the earth” by providing decent work, building community, and restoring environments.

In-depth analysis suggests that the industry has yet to genuinely integrate corporate responsibility as part of its strategy. Brands will need to broaden their focus to one that is opportunity-based, and move from risk management to ethical excellence. This report illustrates how greater corporate responsibility can shape organizational qualities, inspire new business approaches, and create opportunities to use materials that contribute to sustainable development. Alexandra Martini